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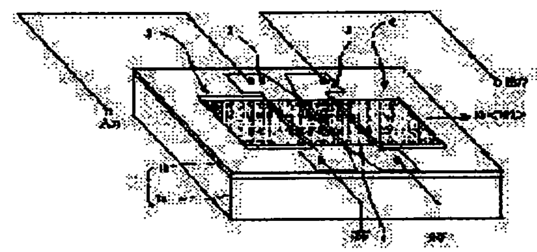
(54) SURFACE ACOUSTIC WAVE ELEMENT AND PRODUCTION THEREOF

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a surface accoustic wave element low in power consumption, low in loss and excellent in wide band characteristics at a low cost by forming the surface of a crystal substrate into specified mirror surface and providing an electrode means with electrode fingers arranged side by side so as to propagate surface elasticity along the direction of a crystal axis.



SOLUTION: The surface of the crystal substrate, on which a piezoelectric crystal thin film 1b is formed, has a mirror surface inclined from a surface 001 at an offset angle . and the electrode means has electrode fingers 4 arranged side by side so as to propagate the surface elasticity along the direction of one crystal axis of the piezoelectric crystal thin film 1b. The surface of an $SrTiO_3$(STO) crystal substrate 1a of a titanic oxide containing strontium Sr to form a piezoelectric crystal thin film 1b of $KNbO_3$(KN) is a mirror surface inclined from the (001) plane at the offset angle . . The input and output interdigital transducers of colmbline electrodes in the electrode means are formed so as to propagate surface acoustic waves along a crystal axis on the piezoelectric crystal thin film 1b, namely, on the (010) plane of KN, preferably, along with the crystal axis large in electromechanical coupling coefficient.

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CLAIMS

[Claim(s)]

[Claim 1] It is the surface acoustic wave device characterized by being the surface acoustic wave device characterized by providing the following, for the surface of said crystal substrate with which said piezoelectric-crystal thin film was formed being a mirror plane which inclined by theta whenever [offset angle] from a field (001), and said electrode means having an electrode finger installed so that surface acoustic waves might spread along the one direction of a crystallographic axis of said piezoelectric-crystal thin film. A crystal substrate of perovskite type structure, spinel type structure, or rock salt type structure An electrode means to generate surface acoustic waves on a piezoelectric-crystal thin film of perovskite type structure formed by chemical vapor deposition on said crystal substrate, and said piezoelectric-crystal thin film

[Claim 2] A surface acoustic wave device according to claim 1 characterized by said piezoelectric-crystal thin film consisting of a crystal of KNbO3.

[Claim 3] A surface acoustic wave device according to claim 2 characterized by said crystal substrate consisting of a crystal of SrTiO3.

[Claim 4] A surface acoustic wave device according to claim 3 characterized by theta being -10 degrees < theta< 10 degrees (theta!=0 degree) whenever [said offset angle].

[Claim 5] A surface acoustic wave device according to claim 4 characterized by the one direction of a component within a field of a crystallographic axis of said piezoelectric-crystal thin film being the direction of an a-axis.

[Claim 6] A surface acoustic wave device according to claim 1 characterized by said crystal substrate consisting of a crystal of MgAl 2O4.

[Claim 7] A surface acoustic wave device according to claim 1 characterized by said crystal substrate consisting of a crystal of MgO.

[Claim 8] The manufacture method of the surface acoustic wave device characterized by to include the production process which forms the mirror plane which inclines by theta whenever [offset angle] from the field (001) of the crystal substrate of perovskite type structure, spinel type structure, or rock salt type structure, the production process which carry out the chemical vapor deposition of the piezoelectric-crystal thin film of perovskite type structure on the mirror plane where said crystal substrate inclines, and the production process which form an electrode means have the electrode finger which installed on said piezoelectric-crystal thin film so that

surface acoustic waves may spread along the one direction of a crystallographic axis of said piezoelectric-crystal thin film.

[Claim 9] A manufacture method of a surface acoustic wave device according to claim 8 characterized by said piezoelectric-crystal thin film consisting of a crystal of KNbO3.

[Claim 10] A manufacture method of a surface acoustic wave device according to claim 9 characterized by said crystal substrate consisting of a crystal of SrTiO3.

[Claim 11] A manufacture method of a surface acoustic wave device according to claim 10 characterized by theta being -10 degrees < theta< 10 degrees (theta!=0 degree) whenever [said offset angle].

[Claim 12] A manufacture method of a surface acoustic wave device according to claim 11 characterized by the one direction of a component within a field of a crystallographic axis of said piezoelectric-crystal thin film being the direction of an a-axis.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] surface-acoustic-waves ****, such as a filter using the surface acoustic waves with which this invention progresses the flat surface of a piezo-electric substrate, a resonator, and an oscillator, -- it is related with the so-called SAW device and its manufacture method.

[0002]

[Description of the Prior Art] Surface-acoustic-waves ******** SAW (Surface Acoustic Wave) is an elastic wave which the energy of a wave concentrates only near the surface of data medium (elastic body), and spreads. Therefore, since the handiness that generating of a wave, detection, and control can be processed on the solid-state surface, and the speed (acoustic velocity) of an elastic wave be several km/second and there be convenience in that the device using SAW can be miniaturized, it be widely applied to electronic communication link components in recent years.

[0003] An example of the SAW device used for electronic communication link components, such as a high pass filter, at drawing 1 is shown. ** of the input which the piezo-electric substrate 1 is required and was formed on it in order to use SAW, or the electrode pair of a pectinate form -- the electrical signal which bears information by 2 -- SAW -- changing -- further -- the pectinate form electrode pair of an output -- by 3, it changes from SAW and takes out as an electrical signal. Each pectinate form electrode pair is formed on the piezo-electric substrate 1 so that the electrode finger 4 may be

installed by turns. SAW spreads in the direction in which the electrode finger 4 is installed side by side. Since conversion efficiency improves as a piezo-electric substrate with the large electromechanical coupling coefficient which shows the effectiveness of electric machine conversion, it gropes for the piezoelectric-crystal material also with current [large / an electromechanical coupling coefficient]. As a substrate which consists of a piezoelectric-crystal material, LiNbO3 and the LiTaO3 grade of the single crystal of the perovskite system material of an oxide which consist of Lithium Li, Potassium K, Tantalum Ta, Niobium Nb, oxygen O, Lynn P, titanium Ti, etc. are used.

[0004]

[Problem(s) to be Solved by the Invention] Recently, it was discovered that KNbO3 (henceforth KN) single crystal is the crystal material which has one 10 times [no less than] the electromechanical coupling coefficients of this, such as LiNbO3 and LiTaO3 crystal. However, since it is difficult to produce the bulk crystal of KN cheaply and in large quantities, examination which carries out thin film crystallization of the KN is performed. then, the liquid phase epitaxy (LPE) which is the conventional forming-membranes method -- although it is possible to obtain KN thin film by law or the spatter -- LPE -- it is difficult to control the thickness of the thin film of micron order by law to high degree of accuracy, and to form membranes. Moreover, although the spatter is excellent in the thickness controllability, while the combination of the target for obtaining KN thin film of the purpose presentation is difficult, the problem that a substrate may receive a damage is in a membrane formation process.

[0005] Thus, by the conventional forming-membranes method, training of KN film is difficult and the surface acoustic wave device using this crystal becomes expensive in many cases. Then, the purpose of this invention is to offer the surface acoustic wave device which has the piezoelectric-crystal thin film of the ferroelectric crystal formed on the crystal substrate by thin film crystal means forming, such as the organic metal chemical-vapor-deposition method (henceforth MOCVD). Furthermore, this invention aims at offering the surface acoustic wave device equipped with the piezoelectric-crystal thin film of perovskite type structures, such as KN of bearing, suitable for a surface acoustic wave device, and its manufacture method.

[0006]

[Means for Solving the Problem] A surface acoustic wave device of this invention A crystal substrate of perovskite type structure, spinel type structure, or rock salt type structure, A piezoelectric-crystal thin film of perovskite type structure formed by

chemical vapor deposition on said crystal substrate, an electrode means to generate surface acoustic waves on said piezoelectric-crystal thin film -- since -- the surface of said crystal substrate with which it is the becoming surface acoustic wave device, and said piezoelectric-crystal thin film was formed (001) It is the mirror plane which inclined by theta whenever [offset angle] from a field, and said electrode means is characterized by having an electrode finger installed so that surface acoustic waves might spread along the one direction of a crystallographic axis of said piezoelectric-crystal thin film.

[0007] In a surface acoustic wave device of above-mentioned this invention, it is characterized by said piezoelectric-crystal thin film consisting of a crystal of $KNbO_3$. In a surface acoustic wave device of above-mentioned this invention, it is characterized by said crystal substrate consisting of a crystal of $SrTiO_3$. In a surface acoustic wave device of above-mentioned this invention, it is characterized by theta being -10 degrees < theta< 10 degrees (theta!=0 degree) whenever [said offset angle].

[0008] In a surface acoustic wave device of above-mentioned this invention, it is characterized by the one direction of a component within a field of a crystallographic axis of said piezoelectric-crystal thin film being the direction of an a-axis. In a surface acoustic wave device of above-mentioned this invention, it is characterized by said crystal substrate consisting of a crystal of $MgAl_2O_4$. In a surface acoustic wave device of above-mentioned this invention, it is characterized by said crystal substrate consisting of a crystal of MgO.

[0009] A production process which forms a mirror plane where a manufacture method of a surface acoustic wave device of this invention inclines by theta whenever [offset angle] from a field (001) of a crystal substrate of perovskite type structure, spinel type structure, or rock salt type structure, A production process which carries out chemical vapor deposition of the piezoelectric-crystal thin film of perovskite type structure on a mirror plane where said crystal substrate inclines, It is characterized by including a production process which forms an electrode means to have an electrode finger installed on said piezoelectric-crystal thin film so that surface acoustic waves might spread along the one direction of a crystallographic axis of said piezoelectric-crystal thin film.

[0010] In a manufacture method of a surface acoustic wave device of above-mentioned this invention, it is characterized by said piezoelectric-crystal thin film consisting of a crystal of $KNbO_3$. In a manufacture method of a surface acoustic wave device of above-mentioned this invention, it is characterized by said

crystal substrate consisting of a crystal of SrTiO3. In a manufacture method of a surface acoustic wave device of above-mentioned this invention, it is characterized by theta being -10 degrees < theta< 10 degrees (theta!=0 degree) whenever [said offset angle].

[0011] In a manufacture method of a surface acoustic wave device of above-mentioned this invention, it is characterized by the one direction of a component within a field of a crystallographic axis of said piezoelectric-crystal thin film being the direction of an a-axis. According to a surface acoustic wave device and its manufacture method of above-mentioned this invention, a surface acoustic wave device equipped with a piezoelectric-crystal thin film of perovskite type structures, such as KNbO3 with a large electromechanical coupling coefficient, can be manufactured cheaply.

[0012]

[Embodiment of the Invention] Hereafter, the example of this invention is explained, referring to a drawing. An example of the surface acoustic wave device of an example is shown in drawing 2 . In the surface-acoustic-waves resonator of this cavity form Crystal substrate 1a of perovskite type structure which gave offset to the substrate (001) of SrTiO3 (henceforth STO) of the titanic-acid ghost containing Strontium Sr as shown in drawing, It confronts each other on KN crystal thin film 1b of the substrate 1 which consists of piezoelectric-crystal thin film 1b of the perovskite type structure which consists of KN formed by chemical vapor deposition on this crystal substrate. The reflectors 5 and 6 arranged on both the IDT(s) outside are formed in the input of the pair of the arranged pectinate form electrode and the output INTADIJITARU transducers (it is called Following IDT) 2 and 3, and a list. An input electrical signal is changed into surface acoustic waves by the input IDT2, and the resonance obtained by going back and forth between reflectors 5 and 6 is drawn by the external circuit changed and connected to the output electrical signal through the output IDT3.

[0013] The surface of STO crystal substrate 1a where piezoelectric-crystal thin film 1b of KN is formed is a mirror plane which inclined by theta whenever [offset angle] from the STO (001) side. the pectinate form electrode IDT which is an electrode means -- surface acoustic waves -- the one direction of the crystallographic axis on the field (010) of piezoelectric-crystal thin film 1b of KN, i.e., KN, -- it is formed so that it may spread in accordance with a crystallographic axis with the electromechanical coupling coefficient it is desirable and large. That is, the electrode finger 4 of IDT is installed by turns along the direction of a

crystallographic axis <100> of KN.

[0014] this example -- the IDT period LT and the reflector grating period LR -- the ratio of the same LT=LR or both -- LT/LR is set up smaller than 1, the frequency fT from which the radiation conductance Ga of the frequency fR and IDT from which reflection coefficient |gamma| of a reflector becomes max serves as max is brought close, and excitation and receiving effectiveness of the surface acoustic waves between IDT and a reflector are increased. Moreover, as a conductive material of IDT and a reflector, using the easy aluminum A1 of light etching processing of mass, thickness raise etching precision, and in order to avoid the fall of the level difference of the resonance peak of a reflector and second peak under the effect of a mass effect (PARUKU wave conversion with IDT, a reflector, etc., inter-electrode multiple echo) by the increment in thickness, the so-called spurious response (SR), and the resonance acutance Q, it be set as 1000A or less.

[0015] MOCVD which uses what gave offset to the substrate (001) of a STO substrate, and is excellent in an example at mass-production nature as shown in drawing 3 -- the single crystal thin film (010) side of KN is grown up on the offset side by law. KN crystal can be grown up so that b-axis orientation of the KN crystal may be carried out and orientation of the a-axis may be carried out into the growth phase surface by this. The one direction of the component within a field of the crystallographic axis of KN crystal thin film turns into the direction of an a-axis. At this time, the direction of an a-axis of KN crystal is as perpendicular as the field made in the direction of a normal of an offset STO substrate, and the <001> directions of STO. An offset angle is <10 degree (theta!=0 degree) whenever [-10 degree <theta], and is four - 7 times or -seven - -4 times preferably. By making surface acoustic waves spread in the direction of an a-axis, <100> bearings where an electromechanical coupling coefficient advantageous to the surface acoustic wave device of KN crystal is big can be used. The lattice constants of KN crystal obtained are an a-axis, a b-axis, and a c-axis, and are a= 5.6896A, b= 3.9296A, and c= 5.7256A, respectively.

[0016] When carrying out epitaxial growth of the crystal film not only MOCVD but on a substrate, it is difficult to be hard to obtain the good epitaxial film which generally carried out orientation to the substrate when the lattice constant of a substrate and a crystal film did not have consistency to some extent, and to attain field (010) growth also in the case of KN. A STO crystal is cubic system and a lattice constant is 3.9051A. Therefore, since KN crystal of orthorhombic system differs from a of KN, and the lattice constant of a

c-axis when growing up it on this STO crystal, for example, even if it carries out crystal growth of the KN to the field (110) of a STO substrate, a-axis orientation of the KN crystal is carried out, and only KN (100) side is acquired. Moreover, upwards good KN crystal growth is difficult for the field (001) of a STO substrate.

[0017] In this example, as shown in using the lattice plane which offset namely, inclined from the STO (001) side, without using the field (001) of STO, and drawing 3 (001), crystal growth of the KN is carried out on the mirror plane which inclined from the field by theta whenever [offset angle] to the <110> directions. Since the lattice constant of a STO crystal is 3.9051A, the lattice constant of the <-110> direction of a STO crystal is twice [root2] as many 5.52259A as this, and becomes close to the lattice constant of the a-axis of KN. However, the ratio c-axis / a-axis of a c-axis [as opposed to / since lattice constant adjustment of a c-axis cannot be taken only now, make it incline from a STO (001) side by theta whenever / offset angle / to the <110> directions, and / the a-axis of the lattice constant of KN] = 5.7256 / 5.6896= 1.00632 is doubled. For example, if theta calculates the value of 5.52259/of ratios of the shaft acquired by theta whenever [over the lattice constant of 5.52259A of the <-110> direction of STO / offset angle] (5.52259-/costheta) to 1 time, 4 times, 5 times, 6 times, 7 times, and 10 degrees whenever [offset angle], 1.000015, 1.00244, 1.00381, 1.00550, 1.00750, and 1.01542 will be obtained, respectively. These values become a thing near the c-axis / a-axis ratio 1.00632 of KN crystal. Therefore, growth of the field (010) of KN is attained on the offset side from the field (001) of STO. When fluctuation of the lattice constant by the temperature of perovskite type structure or fluctuation of a presentation is taken into consideration, it is desirable that theta is -10 degrees < theta< 10 degrees (theta!=0 degree) whenever [above-mentioned offset angle].

[0018] KN crystal film was grown up on the substrate which has concretely the mirror plane offset 5 times from the STO (001) side. The reaction chamber of an MOCVD system is loaded with the STO substrate which makes a principal plane the mirror plane which the field (001) offset 5 times, the temperature up of this is carried out to laying temperature, and the interior of a reaction chamber is decompressed to a setting atmospheric pressure. Namely, as a start raw material A dipivaloylmethanato potassium [K (C11H19O2)] (henceforth K (DPM)), Each of the carburetor of equipment is loaded with pentaethoxy niobium [Nb (OC2H5)5]. By maintaining these start raw material at laying temperature, respectively, make it sublimate or evaporate and it considers as

organometallic compound gas. This is led to the reaction chamber where the STO substrate heated using Ar carrier gas by which control of flow was carried out, respectively has been arranged, the sink was deposited on the substrate and the epitaxial layer of KN was deposited on the substrate as a laminar flow. Moreover, in order to follow oxidation reaction on generation of each oxide from a start raw material, the oxygen of a constant rate may be added to reactant gas. Thus, the substrate 1 as shown in drawing 4 was obtained.

[0019] Although the above example described the case where STO (001) was used as an offset substrate, KN crystal thin film of the same structure can be obtained also with the substrate which made the field (001) of the crystal of Spinel structure, such as a crystal, for example, [(MgO) (aluminum 2O3)] etc., which is cubic system, or rock salt type structures, such as MgO, offset. Moreover, KN piezoelectric-crystal thin film can be formed by forming KTaO3 or KTN (KTaxNb1-xO3 (0< x<1)) as a buffer layer, and forming KN on this first, on the STO substrate of the offset side from (001).

[0020]

[Effect of the Invention] KN which has a big electromechanical coupling factor according to this invention -- MOCVD -- a device with the low power excellent in using the crystal thin film which carried out single crystal growth by law on the crystal substrate of perovskite type structure, spinel type structure, or rock salt type structure, low loss, and a broadband property can be created cheaply. Moreover, compared with the element using a bulk crystal substrate, it excels in mass-production nature and is advantageous also to a miniaturization and integration.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the outline perspective diagram of a surface acoustic wave device.

[Drawing 2] It is the outline perspective diagram of the surface acoustic wave device of the example by this invention.

[Drawing 3] It is the outline perspective diagram of the crystal substrate used for the example by this invention.

[Drawing 4] It is the outline perspective diagram of the crystal substrate used for the example by this invention.

[Description of Notations]

1 Piezo-electric Substrate

2 Three A pectinate form electrode pair, IDT

4 Electrode Finger

5 Six Reflector